CATERPILLAR®

WHERE THE WORLD TURNS FOR POWER

Distributed Generation and Combined Heat And Power

Caterpillar Inc.

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Power Reliability Concerns

"If the energy infrastructure of this country is inadequate or in some way excessively costly, it will undermine economic growth, and is therefore a major issue that must be addressed." *Alan Greenspan, January 26, 2001*

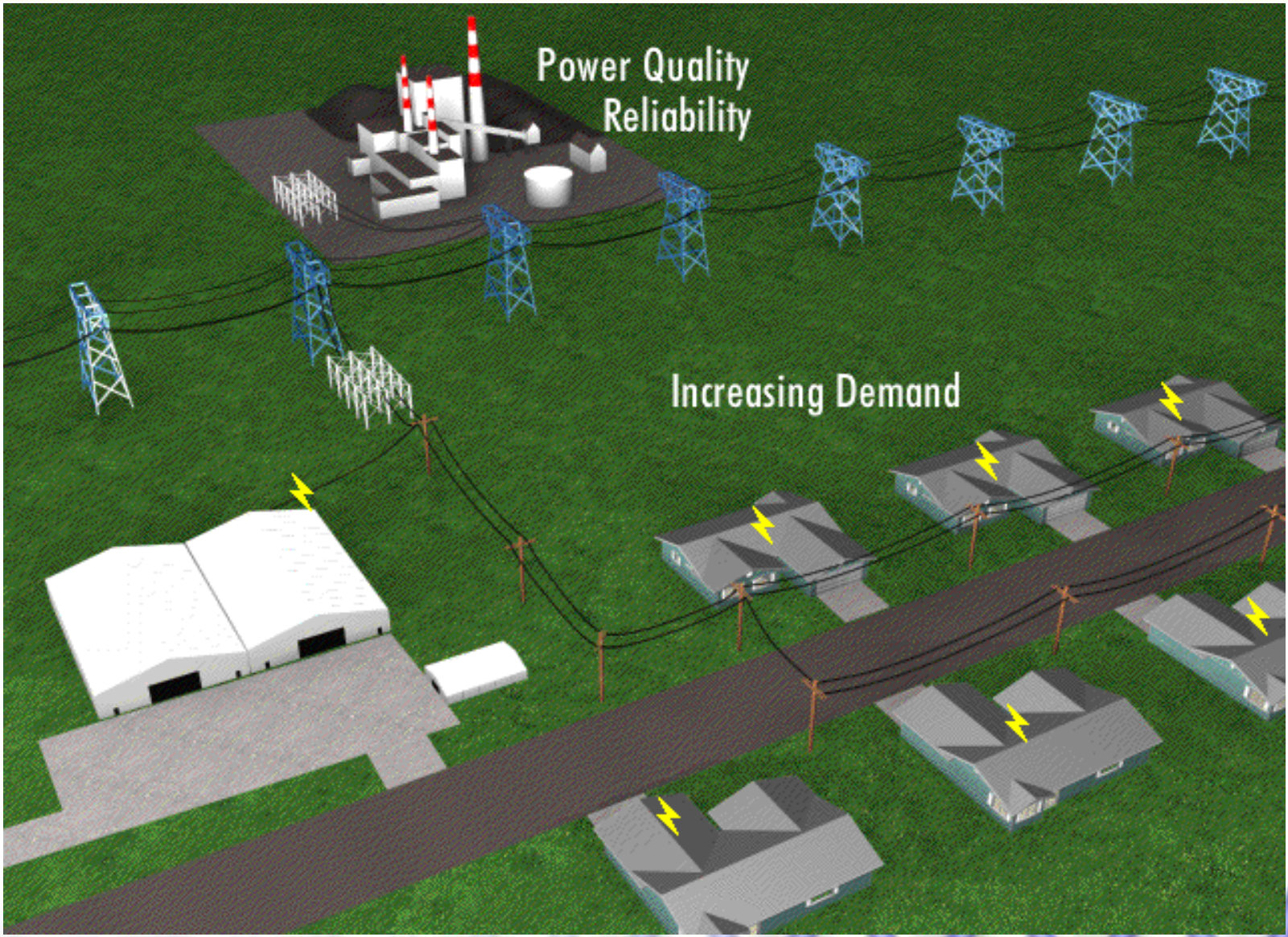
2009 Projections

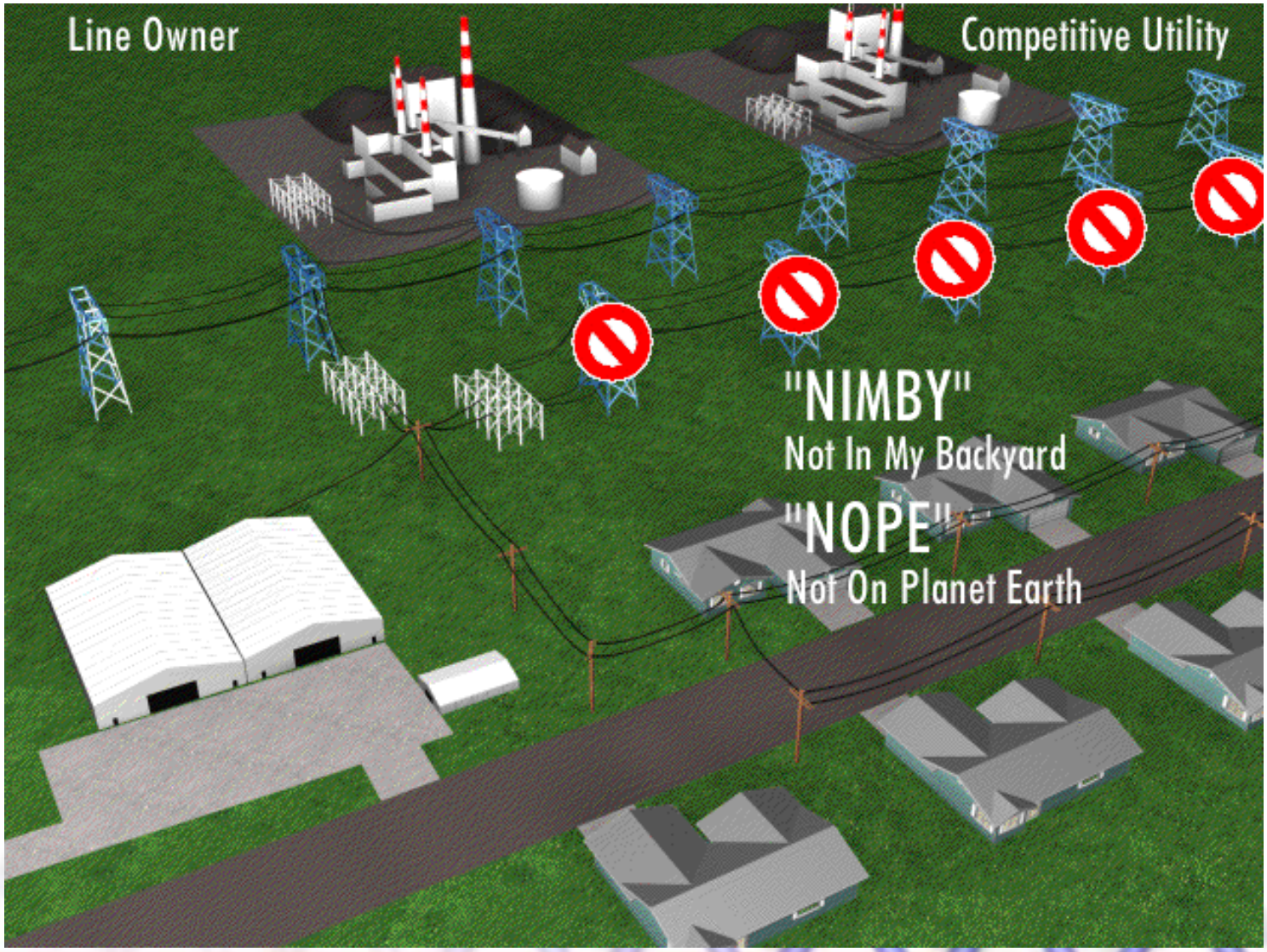
Areas with Capacity Margins < 10 percent

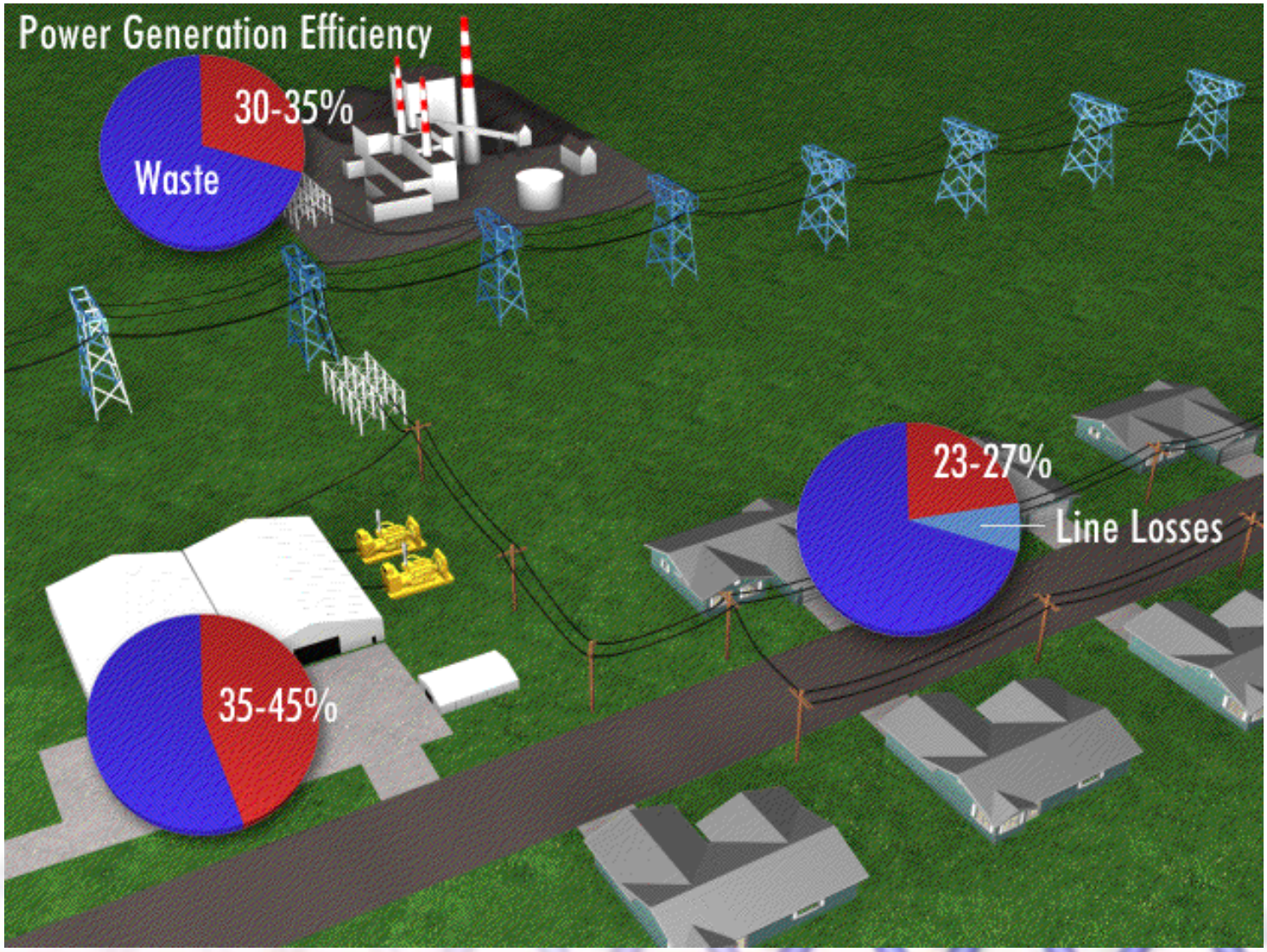
Source: National Electricity Reliability Council, 2000

According To A Contingency Planning Study, The Following Is A Detailed Breakdown Of Major Causes Of Data Loss For Computers:

• Power Failure And Surges	43%
• Storm And Weather	10%
• Fire Related	8%
• Hardware/Software	8%
• Flood And Water Related	7%
• Earth Movement Related	6%
• Network Outage	5%
• Human Error	3%
• HVAC Related	3%
• Other	7%


Power Quality
Reliability
Increasing Demand


Line Owner
Competitive Utility
"NIMBY"
Not In My Backyard
"NOPE"
Not On Planet Earth


Power Generation Efficiency
30-35%
Waste
23-27%
Line Losses
35-45%

What is CHP?

Combined Heat and Power

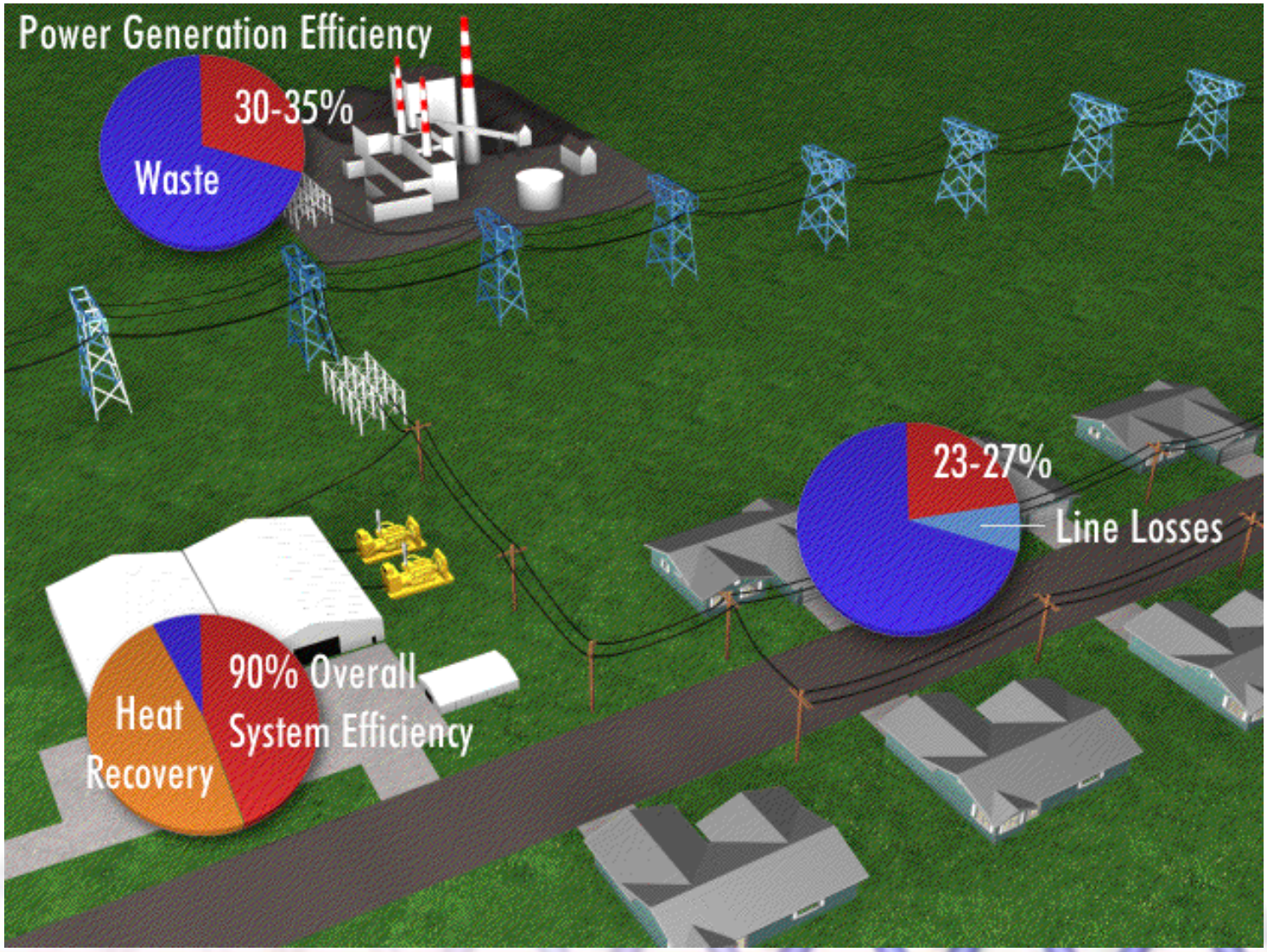
or

Cogeneration

or

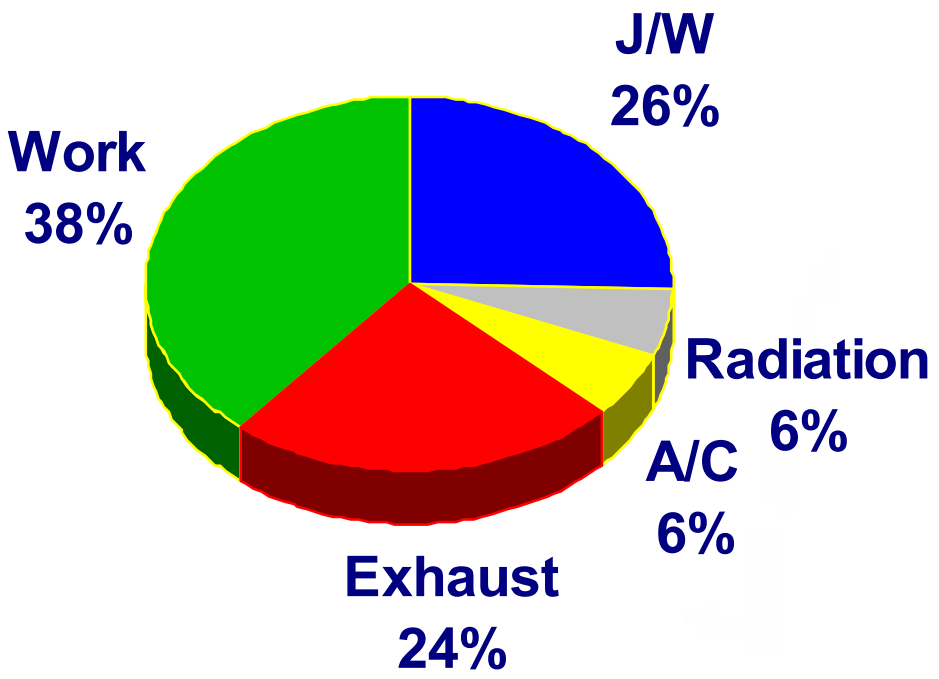
Total Energy

- **Definition: Simultaneous and sequential use of power and heat.**


Power Generation Efficiency
30-35%
Waste
23-27%
Line Losses
90% Overall
System Efficiency
Heat
Recovery

Typical Uses For Heat Recovered

- Hot Water
- Hot Air
- Steam



CHP is an Economic Decision

Decide which is most important: Electrical power or heat recovery

- Some power requirements are sized to meet heat load needs.
- Some system run times are determined by heat load needs.

Bottom Line:
What is the $ value of the heat recovered versus the cost associated with retrieving and distributing the heat.

Cogeneration- Types of Systems

- Reciprocating Engines **(Gas or Diesel)**
  - Hot Water
    - Domestic, 120° F or Higher
  - Low pressure steam
    - 15 psi @ 260 JW
    - 125 psi from Exhaust

Cogeneration- Types of Systems

- Gas Turbines
  - Medium and high pressure steam
    - Typically over 125 psi
- Steam Turbines

Gas Engine Vs. Turbines

- Engine Advantages
  - Higher mechanical efficiency
  - Lower initial investment cost
- Engine Disadvantages
  - Small amounts of medium and high pressure steam available

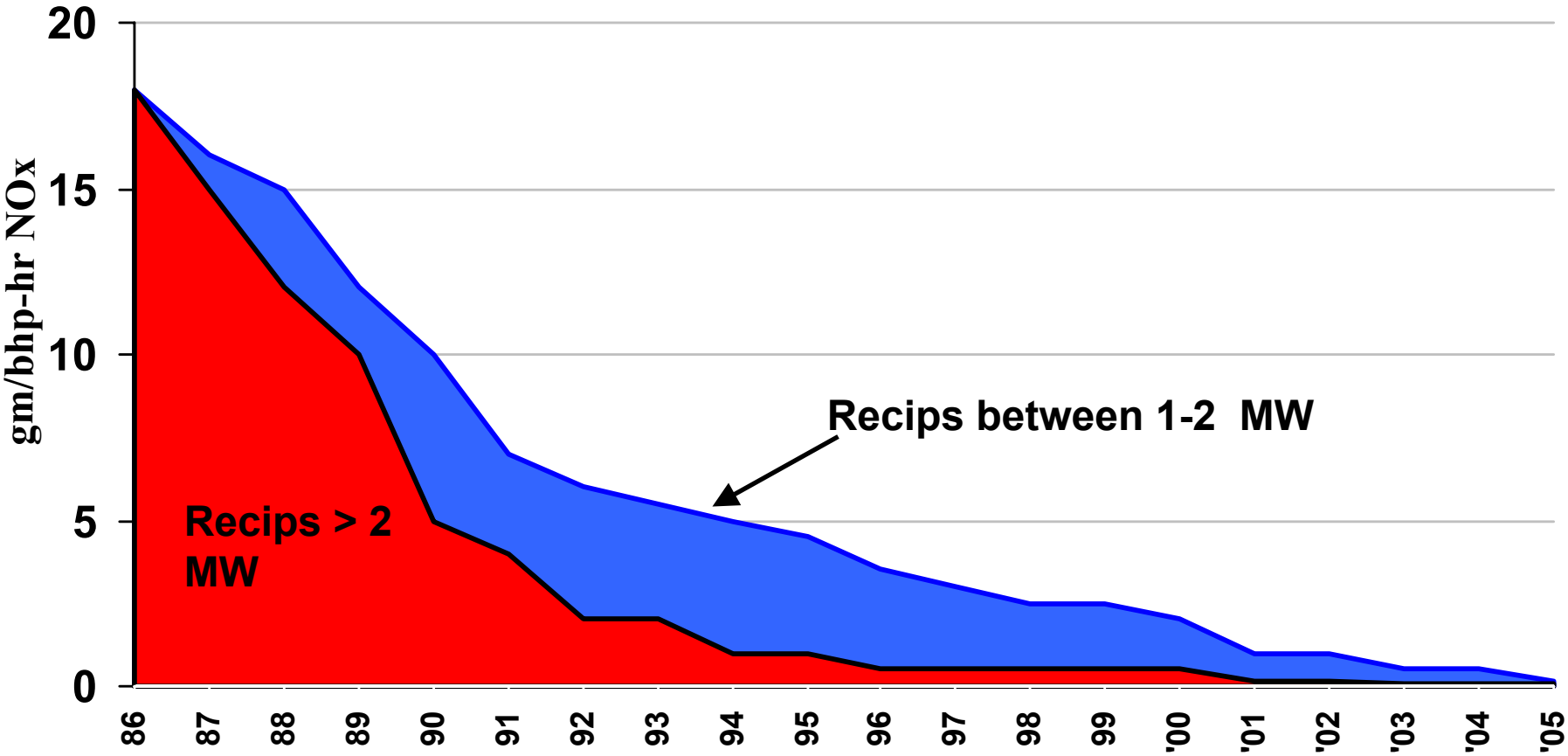
Gas Vs. Diesel Engine

- Engine Advantages
  - Higher mechanical efficiency
  - Lower initial investment cost
- Engine Disadvantages
  - Small amounts of medium and high pressure steam available

DG/CHP Market Barriers

- Legislative
  - The way rules are being written
    - Little consideration for recips
- Regulatory
  - Emissions regulations
- Electric Utilities
  - Electrical interconnects
  - Purchased energy price
    - Avoided cost basis

Worldwide Emissions Trends



Emissions: What to do about Them

- Reduction via Control of Combustion in Engine
  - Advanced Diesel Engines or Lean burn Gas Engines
- Reduction via After-Treatment of Exhaust Gas
  - SCR for NOx Reduction (All Engines except Landfill or Biogas)
  - 3-Way Catalysts for NOx, HC, CO Reduction (Rich Burn Gas Only but No Landfill or Biogas)
  - Oxidation Catalysts for HC & CO Reduction (All Engines except Landfill or Biogas)
  - Thermal reactors for HC & CO (All Engines)
  - Particulate Traps (Typically Only Diesel)

Standard Temperature Water System

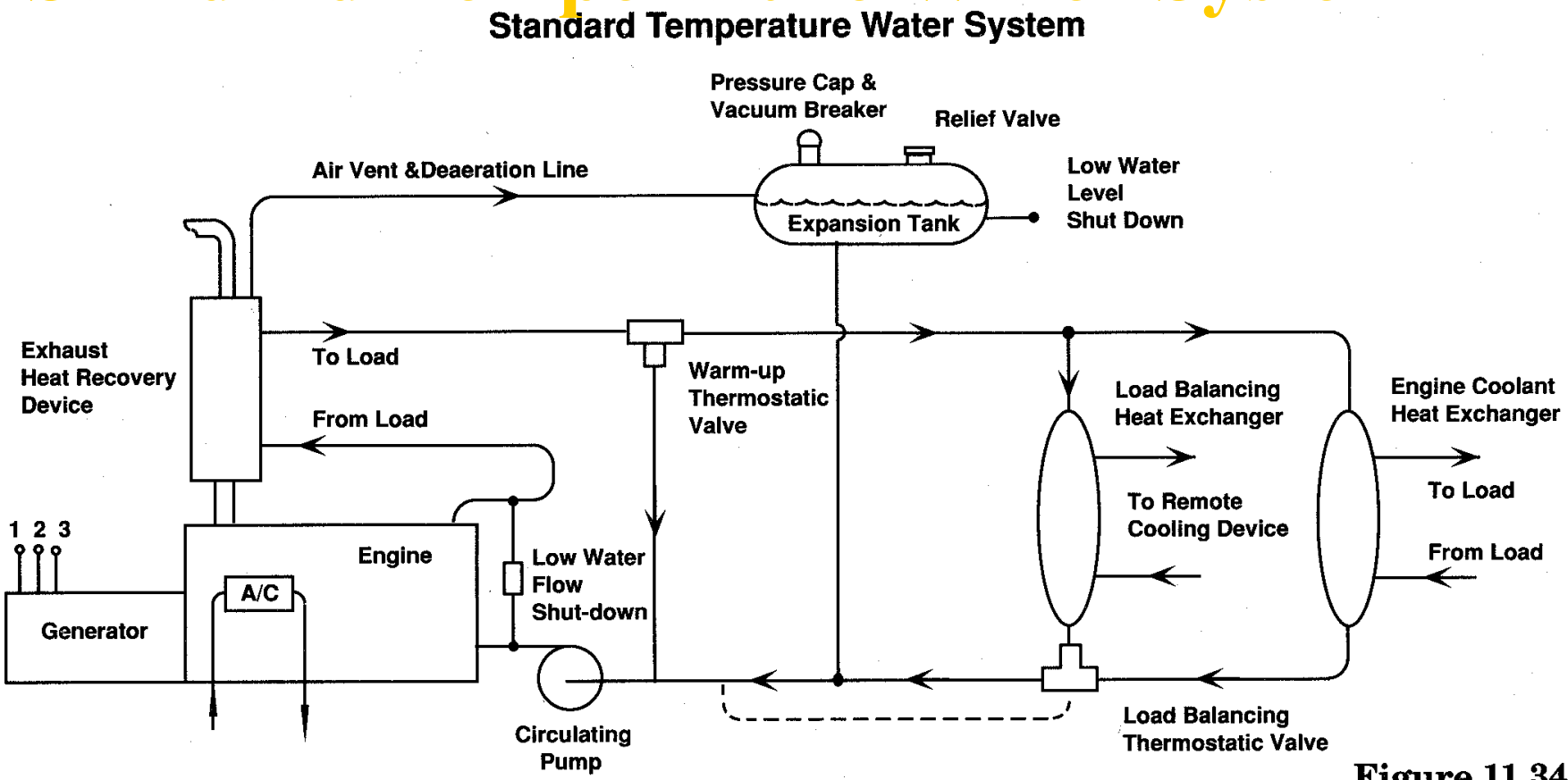
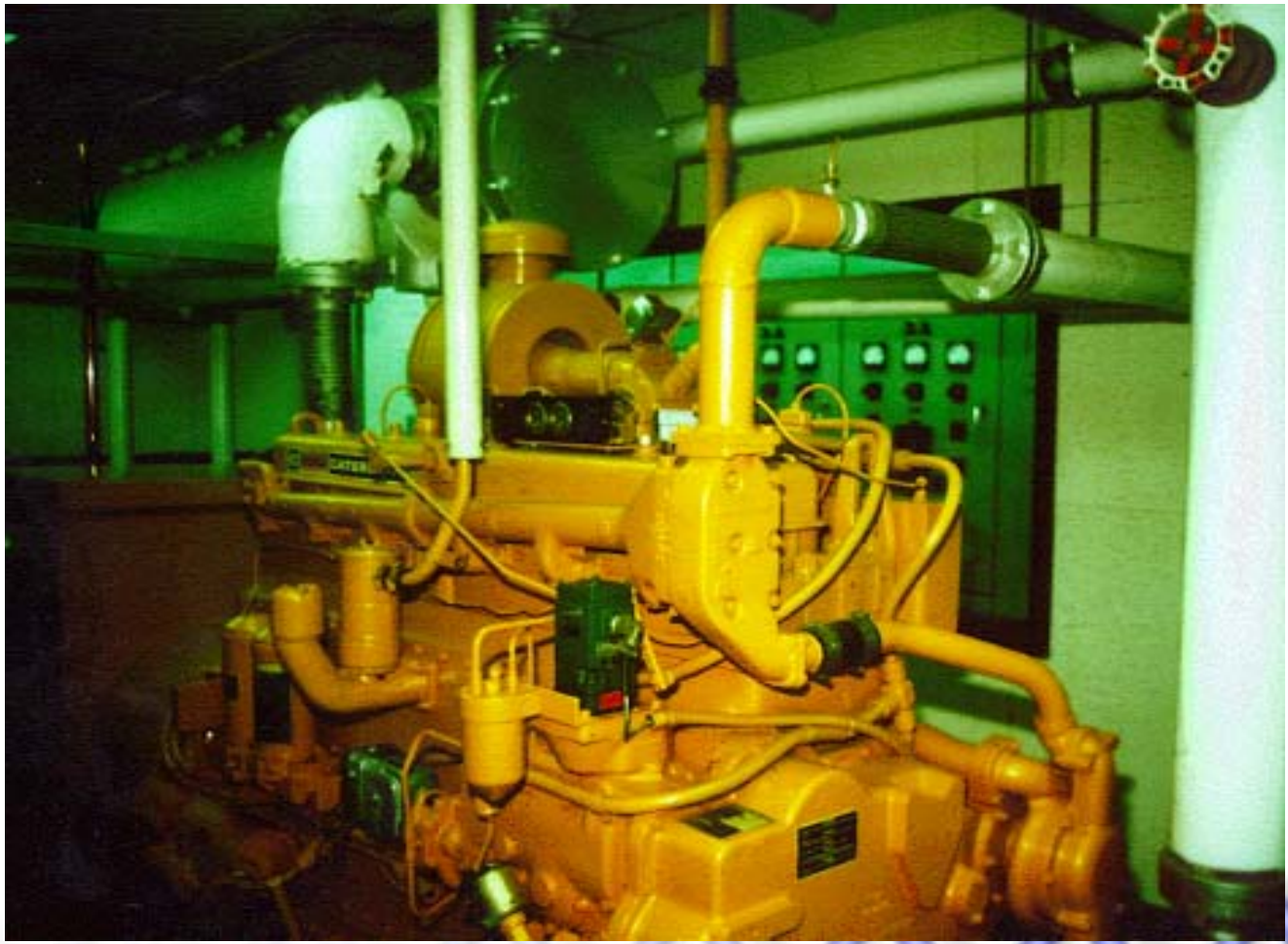


Figure 11.34

Simple CHP Application

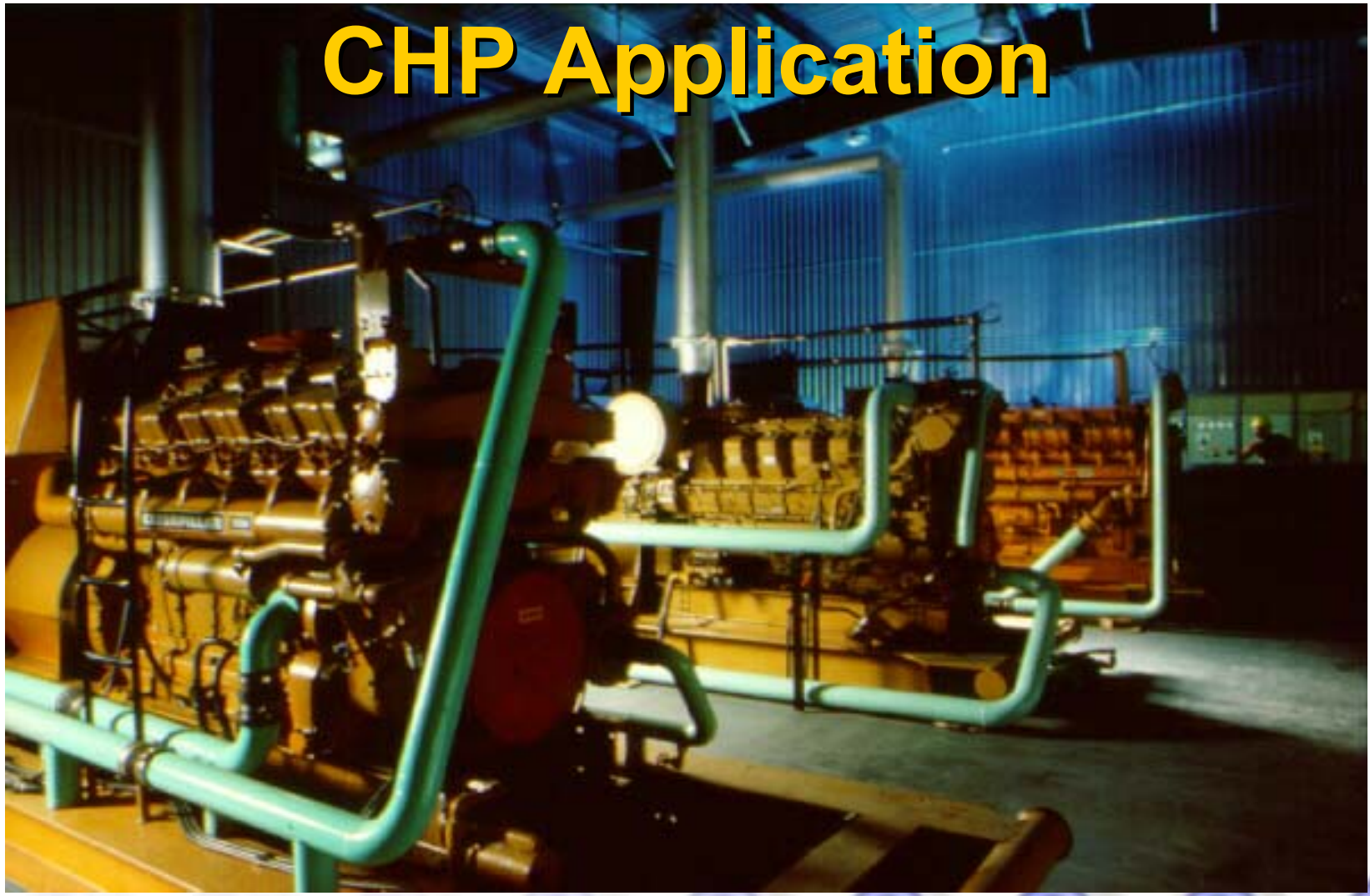


Simple CHP Application
High School in Kansas

Complete CHP Package

1250 ekW CHP System

CHP Application



Industrial CHP Application
Plating facility in Michigan

Absorption Cooling

Absorption Chiller
Hospital chilled water system

CHP Summary

- Know what you want to accomplish before designing a DG/CHP system
- Plan to have the system succeed.
  - Set up maintenance plan
  - Be able to track financial benefits
- Keep it simple
  - It doesn't need to be big to save money!

Questions